USE OF SPATIAL INFORMATION IN 2D SEMG ARRAY DECOMPOSITION

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Abstract

A new feature extraction / classification method for High Density surface ElectroMyoGraphy (HD sEMG) Motor Unit Action Potential (MUAP) decomposition using 2D shape and energy distribution features is presented and experimentally tested.

1 Introduction

With HD sEMG it is possible to investigate both single Motor Units (MUs) as well overall sEMG parameters. This can be useful in the diagnosis of myogenic and neurogenic diseases.

To investigate MU properties derived from a HD sEMG signal, decomposition has to be applied. An often used approach for EMG decomposition is Segmentation – (Feature extraction) – Classification. Segmentation is the extraction of the MUAPs from the sEMG signal. Features (characteristic properties of a MUAP) are not always extracted; classification (assigning MUAPs to their corresponding MU) can be applied either to features or directly to the MUAPs. In literature, 2D spatial information is only marginally used for feature extraction. In this study, spatial energy distribution and MUAP shape information is used as base for feature extraction. The aim of this study was to obtain reliable MUAP templates of sEMG signals obtained during moderate static contractions. The decomposition application was applied to experimental sEMG data recorded with a 2D electrode grid consisting of 32 electrodes.

2 Method

2.1 Feature Extraction

MUAPs differ from each other by shape, amplitude, distribution over the electrode grid and innervation zone. These properties can be summarized in features. Continuous Wavelet Template matching is a proven method to locate MUAPs in an EMG signal and describes both shape and amplitude [2]. Using two different mother wavelets as features (first and second Gaussian derivative), different MUAP shapes can be described. Energy distribution across the electrode grid in both directions can be described by the energy feature of each HD sEMG channel.

Principal component analysis (PCA) was used to reduce redundant information and dimensionality of the estimated features. The resulting combined feature vector was suitable for clustering.

2.2 Clustering

The classification of the MUAPs was performed by clustering the feature space with a classical iterative Expectation – Maximization method [1]. Given a fixed number of classes EM tries to find (Gaussian) clusters of data in the feature space.

3 Results

An experimentally obtained sEMG signal of a m. Vastus Lateralis (10s, 30%MVC) was segmented using an adapted version of the method described in [2]. 349 MUAPs were detected and an EMG expert classified these into 11 clusters (MUs). With the presented method it was possible to estimate 4 MUAP templates correctly (relative error < 0.05) and estimate 4 additional templates reasonably (error < 0.10). The classes that were not detected contained in total only 14 MUAPs. An example of a detected MUAP template matched with the accompanying original template is shown in the figure below.

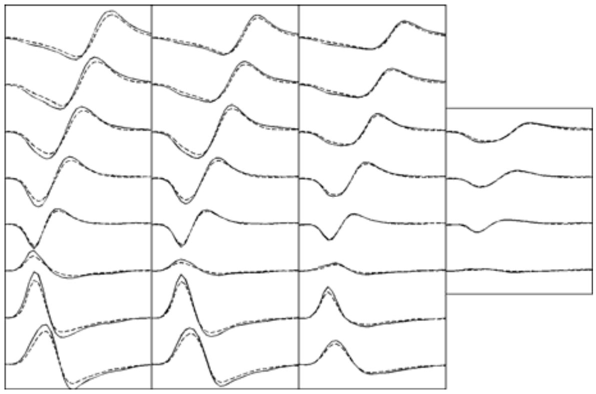

Fig 1. An estimated template and its original template compared

4 Discussion

This study did not focus on complete decomposition (i.e. find all firings of each MU and resolve superimpositions). Even then, using the presented method it was possible to obtain sufficiently reliable MUAP templates. Currently sEMG signals of different muscles and at different contraction levels are used to validate the presented method.

References

[1] Bishop, C. *Neural Networks for Pattern Recognition*, pp 65-73. Oxford Univ. Press, 1995

[2] Gazzoni, M. et al. A new method for the extraction and classification of single MUAPS. *J. Neurosci. Methods,* 136(2),165-177, 2004.